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# Research Note, No. 50

UNITED STATES DEPARTMENT OF AGRICULTURE  
U.S. FOREST SERVICE.

INTERMOUNTAIN FOREST <sup>and</sup> RANGE EXPERIMENT STATION,  
OGDEN, UTAH. +7a

No. 50

December 1957

## SPEEDY SCALING OF LOW-VALUE LOG-LOADS

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Scaling pulpwood log by log seriously reduces the cash return from such a low-value product. On the Falls and Priest Lake Ranger Districts, Kaniksu National Forest, Idaho, scaling hemlock pulpwood (hailed in long log lengths) required a large part of the scaler's already busy schedule at a cost of about 10 percent of the stumpage value of the product. Some way of determining volume was needed that would bring the scaling cost more in line with the value of the logs.

At the district rangers' request, data on load dimensions were obtained in the summer of 1956. The log lengths, number of logs, and circumference of the load, as well as gross scale, were recorded by the scaler for 43 loads as they passed the scaling station. The loads contained an average of 19.4 logs, ranging from 10 to 30 logs per load. Gross scale per load averaged 5.9 M board feet. An average log was 28 feet long and had a scaling diameter of 16.5 inches. The timber from which these loads were cut would have run about five 16-foot logs per thousand board feet.

Analysis of the load data by the Inland Empire Research Center established, in the form of an alignment chart (fig. 1), the relationship between the variables considered. Use of this chart affords a means of estimating quickly the gross volumes of loads of long logs from three simple measurements: circumference of load, number of logs, and average length of logs.

The accuracy of estimate of gross volume obtained from the alignment chart shortcut is in line with the value of the product. The total volume of 43 or more loads can be estimated within 1-1/3 percent of the scaled gross volume two times out of three. Or, to raise the probability, within 2-2/3 percent 95 times out of 100. However, the scaling time can be reduced by about 60 percent.

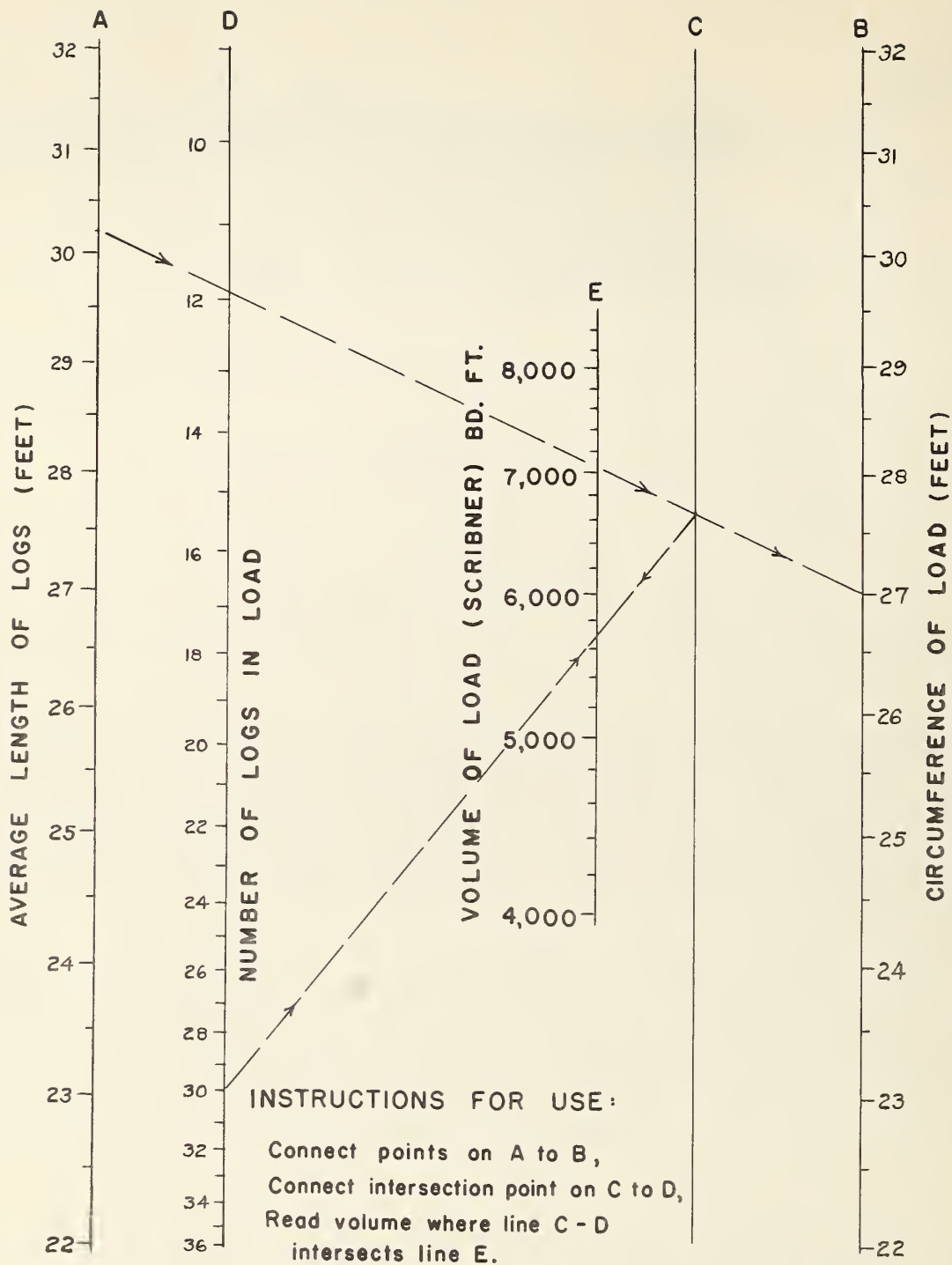


Figure 1.--Alignment chart for determining gross board-foot (Scribner) volume of long log-loads from measurements of average length of logs, load circumference, and number of logs in load.

This alignment chart is applicable with any degree of accuracy only to material similar to that for which the relationship was derived. However, similar solutions could be worked out for other areas and species as need arises.

Sample loads from each sale still would have to be scaled for both gross and net volumes to determine the cull deduction. The intensity of the cull sample would depend on the variability of the cull factor and the size of the sale. A procedure for determining the most economic sampling intensity for such a problem has been described by Lynch.<sup>1/</sup>

#### Statistical Basis for Relationship

The relationship shown in figure 1 was determined by means of a multiple linear regression of the form

$$\text{Log } V = b_1 \text{Log } L + b_2 \text{Log } C + b_3 \text{Log } N + b_0,$$

where V = volume in board feet, Scribner rule

L = average log length in load

C = circumference of load at middle

N = number of logs in load

b<sub>0</sub>-b<sub>3</sub> = coefficients to be computed.

The equation so derived expressed in nonlogarithmic form is

$$V = \frac{L^{0.7012} C^{2.5237}}{3.5968 N^{0.2289}}.$$

This relationship accounts for 68 percent of the variation in load volumes. The standard error of estimate for the regression is 8.7 percent of the volume.<sup>2/</sup> Length and circumference as variables of volume are obviously significant. The exclusion of number of logs in the load as a variable reduced the coefficient of correlation from .84 to .74. Hence the inclusion of number of logs, as an expression of the effect of log size on the board-foot/cubic-foot ratio, is justified. Plotting the residuals from regression against the variable log N showed no trend; so its present form in the equation seemed satisfactory.

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<sup>1/</sup> Lynch, D. W. What is an acceptable allowable error and sample size in sample log scaling or tree measuring? Intermountain Forest and Range Expt. Sta. Research Note 14, 5 pp. 1954.

<sup>2/</sup> Use of logarithms in volume equations introduces a systematic underestimate, the magnitude of which depends on the standard error of estimate. In this case, the correction factor by which the final board-foot volume should be multiplied is only +1.0035. (Meyer, H. Arthur. "A correction for a systematic error occurring in the application of the logarithmic volume equation." Research Paper 7, Penn. State Forest School.)

The reliability of the regression for estimating the total volume was determined by dividing the standard deviation of the load volumes about the regression by the square root of the number of loads,  $\frac{8.75\%}{\sqrt{43}} = 1.33$  percent

(Bruce and Schumacher,<sup>3/</sup> p. 245). This figure represents the maximum amount by which the total estimated volume of 43 or more loads might differ from the scaled volume two out of three times. The standard error in percent for a sale of (n) loads would, in a similar manner, be  $\frac{8.75\%}{\sqrt{n}}$  for a probability of two out of three.

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<sup>3/</sup> Bruce, D., and Schumacher, F. X. 1950. Forest mensuration. Ed. 3. 483 pp., illus. New York and London.